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HEAT EXCHANGER CORROSION TESTS. PHASE II

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INTRODUCTION

A Phase I corrosion test program covering brazed aluminum heat exchanger coils used in military environmental control units (ECU) was completed in 1968. This was prompted by field failures of condensers that were particularly prevalent in coastal areas with atmospheres of high salt content expectancy.

This field exposure study was conducted in the Panama Canal Zone making use of a test console as shown in Figure 1. It provided means of mounting twelve pressurized heat exchangers, with fans to draw equal air volumes thru each at approximately 800 ft/min. face velocity. Through the use of special materials and protective coatings the test life before leakage occurred was increased from an initial two months to twenty two months for this high salt atmosphere. (Report AD-656617, Defense Documentation Center).

The trend of heat exchanger design has been to the fin and tube type for the military ECU's because of cost and reliability factors. It was decided to continue a Phase II corrosion program for the fin and tube design, particularly because of the increase in the use of all aluminum construction commercially and its possible military application. This information is also useful in evaluating the differences in the two basic heat exchanger types when operating under similar exposure conditions. Accordingly the installation, tests, and observations were continued by the Tropic Test Center of the U.S. Army Test and Evaluation Command.

SELECTION OF TEST SITE

The test site location remained the same as for Phase I, the selection having been made by representatives of USAMERDC (then USAERDL) and U. S. Army Tropic Test Center. The test console was located approximately 300 yards from the Caribbean Beach facing the prevailing wind off the water at Fort Sherman, Canal Zone.

Salt-fall conditions vary throughout the world and are heaviest in oceanic islands and coastal areas which have a range of 25-300 lb/acre/yr[1]. Extreme exposure situations produce higher values such as the 4400 lb/acre/yr recorded at the beach breakwater of Fort Sherman approximately 1200 yards from the test site. Salt-fall in the United States is relatively low ranging from 1/2 to 1 lb/acre/yr in the interior portion to approximately 15 lb/acre/yr in the Miami area. Cape Hatteras, N. C. reports 10 lb/acre/yr. Salt-fall at the Fort Sherman heat exchanger test site was relatively heavy at 208 lb/acre/yr based on recordings made in other nearby test sites. Relative humidity ranged from 90 to 100% during night and early morning to 70 to 80 during the daytime. The heat exchanger test site thus represents an accelerated condition for most applications, but provides an exposure representative of heavy salt-fall which would be encountered by some military units in tropical salt environments.

1. :"Atmosphere Sea-salts Design Criteria Areas," by William B. Brierly, U.S. Army Natick Laboratories. October 1965

TEST RESULTS

The general appearance and degree of corrosion attack after exposure to about two years or more on the test console was taken as a measure of the corrosion resistance of the various constructions and coatings. These results are shown on page 4a and photographs of the six test coils remaining on the console at the completion are shown in figures 2-7.

There were no corrosion attributable leaks, although one test coil (no. UAT-II) developed a stress-corrosion type leak at a point of tube flaring. For uncoated construction the all-aluminum type 3003 tube 7072 fin showed less attack than the copper tube-aluminum fin construction (figure 8 & 9). Phenolic coatings of approximately .001" thickness improved resistivity considerably, and the all-aluminum sample with this coating still looked good after thirty-one months exposure.

In general, the evidence of electrolytic type corrosion at copper-aluminum contact points was quite evident, to the extent of destruction of considerable fin areas in some cases. It should be noted that although all-aluminum construction showed less corrosion attack for these test heat exchangers under the isolated test conditions, no attempt was made to evaluate the effect of adjacent or nearby dissimilar metals that may be employed in an ECU system.

It was also interesting to note the results obtained with a special construction brazed aluminum plate and fin exchanger with phenolic coating that had been included after completion of Phase I testing. A total of 63 months of exposure testing was compiled and the condition was good at the termination.

TESTS RESULTS

[illegible] NO.	CONSTRUCTION DESCRIPTION	START NOV. 68		NOV. 70	MAR. 71 (Months	AUG. 71 of	TERMINATE 31 Jul 72 exposure)	APPEARANCE AF[illegible]
A-5	Copper tube (tin plate) alum. fin. [illegible]		18 mo. returned					Extensive cor[illegible] joints. Some [illegible] at face.
A-6	Copper tube alum. fin. Uncoated			X	24 mo. returned			Extensive cor[illegible] joints. Most [illegible] grated at fac[illegible]
F-3	Brazed alum. #100 tube sheet phenolic coated			X	47	52	63	Very good con[illegible]
CCTI	Cu. tube-al. fin Phenolic [illegible]			X	13	19	29	Extensive cor[illegible] joints.
UCT II	Copper tube-al. fin Uncoated			X	13	19	29	Considerable [illegible] at tube fin j[illegible]
CAT II	Alum. tube al. fin. Uncoated			X	13	Remove 19		Appearance fa[illegible] sion at fin-t[illegible] leak where fl[illegible] port plate.
A-1	Al. tube-al. fin Heresite coated	Returned 6 mo.	Change fittings & return to Pan.	[illegible]	15	21	31.5	Condition app[illegible] corrosion on [illegible] adjacent coil[illegible]
A-4	Al. tube-al. fin Uncoated		Change fittings & return to Pan.	X	15	21	31.5	[illegible] Slight [illegible]
[illegible]	Copper tube - copper fin. Uncoated		[illegible] to Pan.		4	10	19	[illegible] general [illegible] Some [illegible] co[illegible]
				On test X				

TESTS RESULTS

CONSTRUCTION DESCRIPTION	START NOV. 68		NOV. 70	MAR. 71	AUG. 71	[illegible] 31 Jul 72	APPEARANCE AFTER TEST
Copper tube (tin plate) alum. fin. Coated		18 mo. returned		(Months	of	exposure)	Extensive corrosion at tube joints. Some fins disintegra[illegible] at face.
Copper tube alum. fin. Uncoated			X	24 mo. returned			Extensive corrosion at tube joints. Most of fins dis[illegible] grated at fa[illegible].
Brazed alum. #100 tube sheet phenolic coated			X	47	52	63	Very good condition.
Cu. tube-al. fin [illegible]			X	13	19	29	Extensive corrosion [illegible] joints.
Copper tube-al. fin Uncoated			X	13	19	29	Considerable co[illegible] at tube fin joints.
Alum. tube al. fin. Uncoated			X	13	Remove 19		Appearance fair[illegible] sion at fin-tube leak where flari[illegible] port plate.
Al. tube-al. fin Heresite coated	Returned 6 mo.	Change fittings & return to Pan.	X	15	21	31.5	Condition appears go[illegible] corrosion on edge fi[illegible] adjacent coil.
Al. tube-al. fin Uncoated		Change fittings & return to Pan.	X	15	21	31.5	[illegible] Slight [illegible]
Copper tube - copper fin. Uncoated		[illegible] to Pan.		4	10	19	[illegible] Some [illegible] corrosion [illegible]
			On test X				

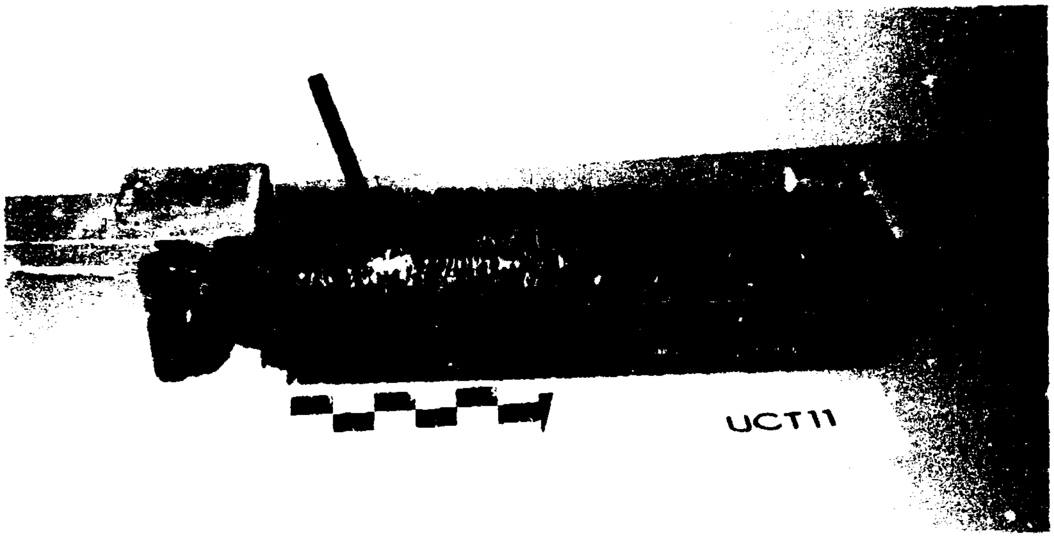

Figure 2. Condenser UCTII Showing White Oxide Coating

Figure 3. Condenser A4 Showing White Oxide Coating

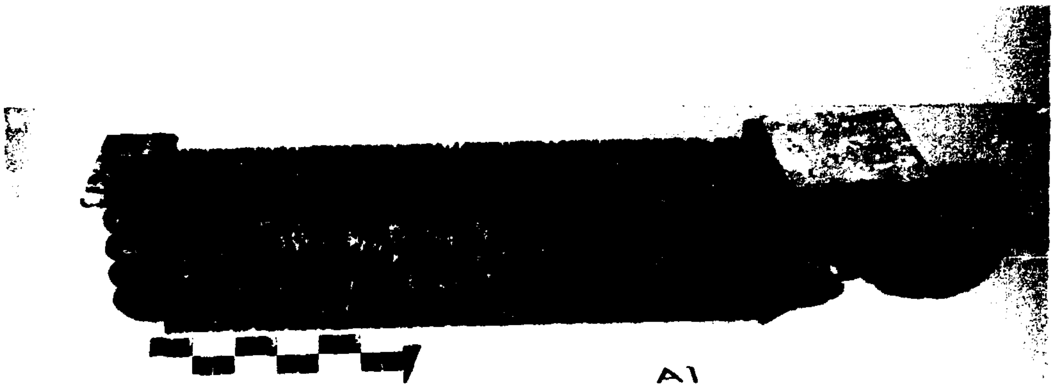

Figure 4. Condenser A1 Showing White Waxy Substance and Debris on Fin Surfaces

Figure 5. Condenser ASC1 Showing Green [illegible] of Aluminum Oxide

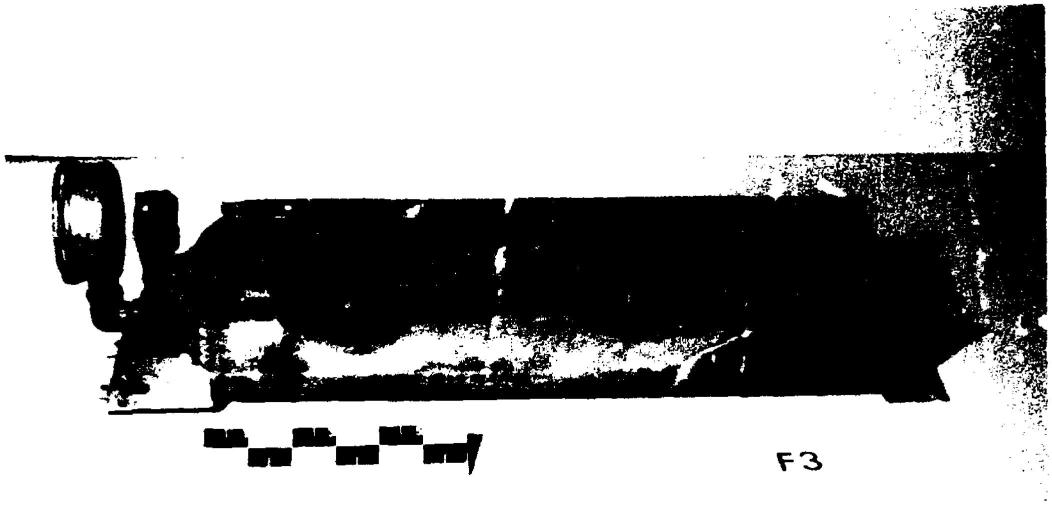

Figure 6. Condenser F3 Showing White Oxide on Fin Surfaces and Corrosion on Joints

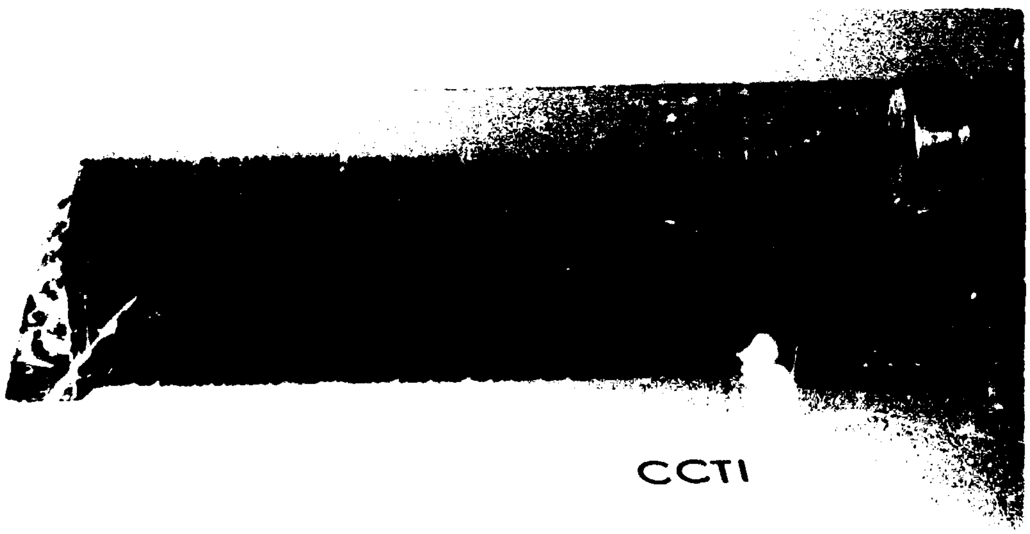

Figure 7. Condenser CCTI Showing White Oxide and Debris Accumulation on Fin Surfaces

CONCLUSIONS AND RECOMMENDATIONS

The results of this test program indicate that all-aluminum condensers may be substituted for the copper tube-aluminum fin construction currently used in military ECU's in the interest of cost savings. However, care should be excercised at the tube joint with any dissimilar metals, which should be protected with a moisture proof external seal.

In the event of a production run of ECU's with all-aluminum condensers, it is recommended that one unit be installed in the Fort Sherman or other suitable Panama area for observation during a two year period.